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ORIGINAL ARTICLE

Assessment of POPSAVEIT in lower extremity vascular injuries in Zagazig University

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ABSTRACT

Background: Traumatic injury of popliteal artery records the highest risk of lower extremity loss with amputation rates of 10% to 15%. A method to investigate the predictors of amputation is needed because previous scores could not be validated. The goal of this review is to investigate if POPSAVEIT (popliteal scoring assessment for vascular extremity injuries in trauma) may be used as a preoperative indicator of amputation risk in patients with traumatic injury of popliteal vessel. **Methods:** From 2017 to 2022, all patients who underwent surgical repair of popliteal arterial traumatic injuries at Zagazig University Hospitals were included in this retrospective study. Patients who needed amputation were assessed to those with limb salvage. Based on univariate analysis, the significant predictors of POPSAVEIT variables for amputation were included in a multivariable analysis. To determine low vs. high-risk scores, receiver operating characteristic (ROC)curve are created. **Results:** 76 patients were included in the study, with an overall amputation rate of 18.4%. The following risk factors were shown to be independently related with amputation: systolic blood pressure <90 mm Hg (OR, 5.3; P = 0.05), associated orthopedic injury (OR, 6.1; P = 0.009), and a lack of preoperative pedal Doppler signals (OR, 8.3; P = 0.001). For a high risk of amputation, a score of ≥3 was determined to have the best sensitivity (78.6%) and specificity (59%). **Conclusions:** POPSAVEIT is a preoperative simple and practical way to classify patients into low- and high-risk major amputation categories.

Keywords: POPSAVEIT; Lower extremity trauma; Popliteal artery; Popliteal injury; Vascular trauma

INTRODUCTION

Traumatic popliteal artery injury accounts for 20% of the lower extremity vascular injuries **[1,2]** associated with serious mangled extremities sequelae and 14% to 25% major amputation rate **[3-6]**. Recent studies have attempted to determine whether individuals may benefit from surgical repair or primary amputation **[7-12]**. Mangled Extremity Severity Score (MESS) is currently the most widely utilized scoring system in the world for both upper and lower extremity injuries, to identify patients whose candidates for limb salvage. Following a retrospective examination of patients with lower mangled extremities, Johansen et al. developed MESS in 1990 **[11]**. However, it is a complicated score, and many factors necessitate specialized surgical evaluation, which may not be possible before surgery **[6]**. In 2018, Loja et al. **[7]** designed PROOVIT (prospective vascular injury therapy) as a modification of the MESS and demonstrated that MESS failed to predict the need for amputation effectively **[12].** POPSAVEIT was detailed by O'Banion et al. **[13],** in which shock (systolic blood pressure (SBP) of <90 mm Hg), associated orthopaedic (concurrent ipsilateral fracture) injuries, and a lack of preoperative distal foot pulse or Doppler signals are all factors in the score, and are all independently associated to a higher risk of amputation. **(Table 1)**. The POPSAVEIT (popliteal scoring assessment for vascular extremity injuries in trauma) is being used as a risk stratification tool to investigate perioperative factors that may influence limb salvage outcomes **[13]**. This study evaluates the validity of POPSAVEIT as preoperative predictor of the risk of amputation in patients with traumatic popliteal vascular injuries.

Table 1: POPSAVEIT Score:

Risk factors	Points
An initial SBP of <90 mm Hg	1
A concurrent ipsilateral fracture	2
Absence of pedal Doppler signals	2
Absence of a palpable pedal pulse if the Doppler examination findings were not available	1
Score of ≥ 3 associated with high risk of amputation	

METHODS

The present retrospective study was conducted at Zagazig University Hospitals. It includes all patients who underwent surgical reconstruction of traumatic injury of the popliteal artery from 2017 to 2022. The study protocol was approved by the local ethical committee of Zagazig Faculty of Medicine. The study protocol was approved by the local ethical committee of Zagazig Faculty of Medicine, the data collected from our vascular database.

The patients whose had primary amputation for unsalvageable limb, patients with isolated popliteal venous injury and patients with missing data or lost to follow up were excluded from the study.

The demographic data, patient comorbidities and trauma scenario including mechanism of injury (crushing, blunt and penetrating injury), location of injury (P1, P2 and P3), affected vessel either the artery alone or both artery and vein and orthopedic injury details were collected from our data base

The orthopedic injury mechanisms are differentiated as floating knee, tibial plateau fracture or knee dislocation of the ipsilateral lower limb. These injuries are categorized by the Gustilo classification as, it is the most universally used classification system of open fractures.

The preoperative parameters as SBP, laboratory values, vascular examination findings (the presence or absence of pedal Doppler signals) and associated motor and sensory examinations were reported.

The vascular reconstruction details collected were inflow/outflow vessels, vein versus graft used and fasciotomy details including whether it was done before or after reconstruction and the status of different muscle groups. MESS and POPSAVEIT were calculated from the already available vascular database.

The post-operative parameters included the changes of SBP, vascular examination findings, sensorimotor deficit, and patency data. Patency data was collected from the database as documented by the surgical team at the patient's follow-up visits. This was done by presence of distal pulse clinically, handheld doppler and/or Doppler ultrasound.

STATISTICAL ANALYSIS

SPSS version 23.0 is used to conduct statistical analysis. Frequencies and percentages are used to report categorical variables. For continuous data, the mean ± standard deviation is presented for normally distributed variables, whereas the median and interquartile range (IQR) are reported for non-normally distributed variables. The categorical variables are analysed using the chi square test and the Fisher exact test. For non-normally distributed continuous variables with two unpaired groups, the Wilcoxon rank sum test is used, while for regularly distributed continuous variables, the independent t test is used.

In a multivariable logistic regression, variables of POPSAVEIT that were preoperative predictors of major amputation on univariate analysis ($P<0.05$) are included.

A receiver operating characteristic (ROC) curve is created using the score validation group to evaluate POPSAVEIT's ability to differentiate for major amputation and to define the optimal threshold for a low- vs. high-risk score that would provide the greatest sensitivity and specificity.

RESULTS

A total of 76 patients were admitted to the hospital with traumatic popliteal vascular injuries and met the study criteria. The patients whose had primary amputation for unsalvageable limb (15 patient), patients with isolated popliteal venous injury (7 patient) and patients with missing data (10 patients) or lost to follow up (14 patients) were excluded from the study. The mean age was 35.8±11.5 years, with 52 men (68.4%) and an overall major amputation rate of 18.4%. (14 patients). The baseline demographics and comorbidities of patients requiring amputation and those who had salvageable limb were not significantly different. **(Table 2)**.

The site of injury was documented as P1 (adductor canal to upper border of patella) in 5 patients

(6.5%), P2 (upper border of patella to the knee line) in 19 patients (25%), P3 (the knee line to the emergence of anterior tibial artery) in 21 patients (27.6%), both P1 and P2 segments in 11 patients (14.5%), both P2 and P3 segments in 10 patients (13.2%) and the whole popliteal length (P1, P2 and P3) in 10 patients (13.2%). **(Table 3)**.

The vascular traumas demonstrated isolated popliteal artery injury (n 42, 55.3%) and concurrent arterial and venous injury (n 34; 44.7%). Furthermore, 58 patients (76.4%) had a concurrent ipsilateral fracture, while 18 patients (23.6%) had a penetrating injury without an associated fracture. **(Table 3)**.

The mean MESS and POPSAVEIT were significantly higher in patients requiring amputation than those with successful limb salvage. **(Table 4).** Of the 76 patients, 18 (23.6%) had reported SBP of <90 mm Hg. **(Table 5)**.

Of the 34 (44.7%) patients with accompanying venous injury, ligation was performed in 8 (10.5%), primary repair was performed in 26 (34.2%). Definitive surgical arterial reconstruction involved primary repair in 4 patients (5.3%), interposition repair in 43 (56.6%) and bypass in 29 patients (38.2%). Venous conduit was utilized in 94.7% of the cases, with only 5.3% receiving a prosthetic conduit. There was no significant difference documented between patients requiring amputation and those who had successful limb salvage as regard to the fasciotomies that are achieved either immediate at time of operation or delayed **(Table 6)**. On univariate analysis, the factors associated with amputation were SBP of <90 mm Hg, concurrent ipsilateral fracture, the absence of detectable preoperative pedal Doppler signals and postoperative pedal pulsation, perioperative sensorimotor deficit, length of injured segment, ischemia time before operation and the loss of primary patency. **(Table 2-7).** POPSAVEIT variables are only subsequently incorporated in the multivariate model.

On multivariate regression, the perioperative factors that formatting POPSAVEIT were significant independently correlated with major amputation contain SBP of <90 mm Hg, concurrent ipsilateral fracture, and the absence of detectable preoperative pedal Doppler signals. **(Table S1)**.

At one year, the overall primary patency rate was 76.3 % (58 of 76 patients) **(Table 7, Figure 1)**. 14 (18.4%) of the 18 patients who already had lost primary patency required a major amputation, and all of them had lost primary patency within 30 days of the surgical reconstruction.

ROC curve had an AUC of 0.803 and a score of >3 was observed the maximum sensitivity (78.6%) and specificity (59.3%) for a high risk of amputation **(Figure 2)**.

Table 2: Demographic Data and comorbidities:

		Total (no=76)	Amputated limb (no=14)	Salvageable limb (no=62)	P Value
Age (Mean± SD)		35.8±11.5	33.86±9.6	36.27±11.9	0.48
Sex	**Male (%)**	52 (68.4)	12(85.7)	40(64.5)	0.203
	Female (%)	24 (31.6)	2(14.3)	22(35.5)	
BMI (Mean± SD)		26.9±5.2	26.07±4.7	27.1±5.3	0.5
Diabetes mellitus (%)		11 (14.5)	2(18.2)	9(81.8)	1
Coronary artery disease (CAD) (%)		4 (5.3)	1(25)	3(75)	0.56
Hypertension (%)		11 (14.5)	2(18.2)	9(81.8)	1
Smoking (%)		19 (25)	4(21.1)	15(78.9)	0.74

Table 3: Univariate analysis of trauma Scenario

		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
Injury mechanism	**Crushing**	45 (59.3)	13(28.9)	32(71.1)	0.102
	Blunt	13 (17.1)	1(7.7)	12(92.3)	
	Penetrating	18 (23.6)	0	18 (100)	
Injury location	**P1**	5 (6.5)	0	5(100)	**0.04**
	P2	19 (25)	1(5.2)	18(94.8)	
	P3	21 (27.6)	2(9.5)	19(90.5)	

		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
	P1+P2	11 (14.5)	1 (9.1)	10 (90.9)	
	P2+P3	10 (13.2)	2 (20)	8 (80)	
	P1+P2+P3	10 (13.2)	8 (80)	2 (20)	
Affected vessel	**Artery**	42 (55.3)	8(19)	34(81)	0.87
	Artery and Vein	34 (44.7)	6 (17.6)	28(82.4)	
Concurrent ipsilateral fracture		58 (76.4)	14 (24.1)	44 (75.9)	**0.005**
Type of orthopedic injury	**No**	18 (23.6)	0	18(100)	**0.007**
	Tibial plateau Fr.	23 (30.4)	4(17.4)	19(82.6)	
	Knee dislocation	13 (17.1)	1(7.7)	12(92.3)	
	Floating knee	22 (28.9)	9(40.9)	13(59.1)	

Table 4: Univariate analysis of preoperative score

		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
	No open fracture	18 (23.6)	0	18(100)	
Gustilo scale	**I**	4 (5.3)	0	4(100)	0.39
	II	15 (19.7)	1(6.7)	14(93.3)	
	IIIa	14 (18.5)	3(21.4)	11(78.6)	
	IIIb	20 (26.4)	8(40)	12 (60)	
	IIIc	5 (6.5)	2(40)	3(60)	
MESS	**Mean± SD**		7.5±1.2	5.66±1.3	**0.04**
POPSAVEIT score	**Mean± SD**		3.9±0.8	2±0.6	**0.01**

Table 5: Univariate analysis of preoperative parameters

		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
Sensorimotor deficit	**No**	23 (30.4)	10 (43.5)	13 (56.5)	**0.009**
	Yes	53 (69.6)	4 (7.5)	49 (92.5)	
Pedal doppler signals	**No**	15 (19.7)	12 (80)	3 (20)	**0.001**
	Yes	61 (80.3)	2 (3.3)	59 (96.7)	
SBP	**<90mm Hg**	18 (23.6)	10 (55.5)	8 (44.5)	**0.01**
	>90mm Hg	58 (76.4)	4(6.8)	54(93.2)	
Ischemia time to OR (hours)		11.1±5.05	12.14±5.18	7.9±2.038	**0.05**

Table 6: Univariate analysis of operative Details

Type of repair		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
Vein	**No**	34 (44.7)	6 (17.6)	28 (82.4)	0.269
	primary	26 (34.2)	5(19.2)	21(80.8)	
	Ligation	8 (10.5)	1(12.5)	7(87.5)	
Artery	**primary**	4 (5.3)	0	4 (100)	0.213
	Bypass	29 (38.2)	8(27.6)	21(72.4)	

Type of repair		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
	Interposition	43 (56.6)	6(14)	37(86)	
Inflow vessel	**SFA**	6 (7.9)	0	6 (100)	0.64
	BK	46 (60.5)	6(13)	40(87)	
	AK	24 (31.6)	8(33.3)	16(66.7)	
outflow vessel	**BK**	64 (84.2)	10(15.6)	54(84.4)	0.148
	Tibial	12 (15.8)	4(33.3)	8(66.7)	
Conduit	**Venous**	72 (94.7)	13(18.3)	59(81.7)	0.738
	Prosthetic	4 (5.3)	1(25)	3(75)	
Fasciotomy	**No**	26 (34.2)	6(23.1)	20 (76.9)	0.39
	Immediate	34 (44.7)	7(20.6)	27(79.4)	
	Delayed	16 (21.1)	1 (6.2)	15 (93.8)	

SFA: Superficial femoral artery BK: Below knee AK: Above knee

Table 7: Univariate analysis of postoperative parameter

		Total n (%)	Amputated limb (no=14)	Salvageable limb (no=62)	P value
Pedal pulsation	**Yes**	59 (77.6)	2 (3.4)	57 (96.6)	**0.008**
	No	17 (22.4)	12 (70.6)	5 (29.4)	
Pedal signals	**Yes**	66 (86.8)	4 (6.1)	62 (93.9)	**0.001**
	No	10 (13.2)	10 (100)	0	
Primary patency	**12 months**	58 (76.4)	0	58 (100)	**0.001**
	Days	285.07±141.6	8.9±5.6	347.4± 56.4	**0.001**
Sensorimotor deficit	**Impaired**	6 (7.9)	3 (50)	3 (50)	**0.02**
	Yes	11 (14.5)	11 (100)	0	
	No	59 (77.6)	0	59 (100)	

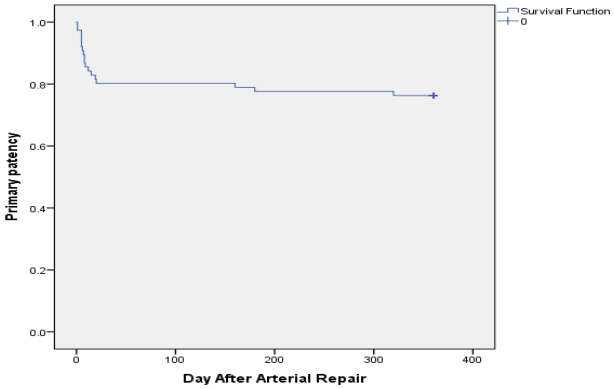

Figure 1: Overall primary patency

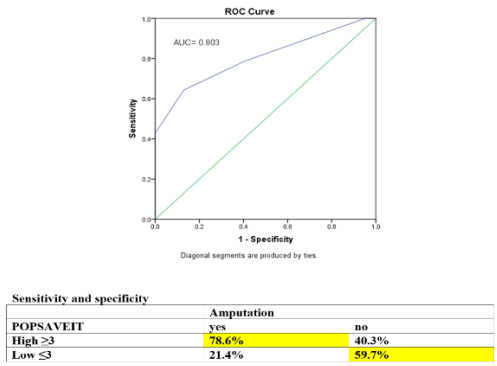

Figure 2: Receiver operating characteristic (ROC) curve

DISCUSSION

Popliteal injuries are the commonest cause of lower extremity vascular traumatic amputation. Consequently, preoperative evaluation is essential to predict and avoid amputation **[13]**.

Multiple scoring systems during the last decades as the MESS, NISSA (nerve injury, ischemia, soft-tissue injury, skeletal injury, shock, and age of patient) score, among other scores were studied to evaluate success of reconstructing of lower extremities trauma with concomitant vascular and orthopedic injuries during the preoperative assessment and the ability to predict the best

decision either reconstruction or primary amputation **[11]**.

Numerous subsequent trials demonstrated that MESS is not sensitive and specific enough to guide the surgical decision and predict limb salvage which lead to more studies of different scoring systems to try to find a more sensitive and specific predictors of amputation **14,15]**.

The first report by O'Banion et al. **[13]**, evaluated all popliteal vascular injury patients in 11 hospitals, and found 16% amputation rate, identifying the POPSAVEIT as a promising new reporting standard. We evaluated this scoring system by retrospectively assessing our cohort of patients who underwent surgical reconstruction of traumatic injury of the popliteal artery from 2017 to 2022.

Our series demonstrated an amputation rate of 18.4% which is comparable to the amputation rate recorded by O'Banion et al. **[13]** and it is comparable to current international rates published in different series **[16-19]**.

In our study, on univariate analysis, SBP of <90 mm Hg, concurrent ipsilateral fracture, the absence of detectable preoperative pedal Doppler signals and postoperative pedal pulsation, perioperative sensorimotor deficit, length of injured segment, ischemia time before operation, and the loss of primary patency were all associated with amputation.

On multivariate analysis, POPSAVEIT factors were found to be correlated with amputation. This is comparable to the finding identified by O'Banion et al. **[13]** as strongly predictive determinants for amputation, confirming the findings of previous recent trials **[20-23]**.

In our study, ROC curve had an AUC of 0.803 and a score of >3 was observed the maximum sensitivity (78.6%) and specificity (59.3%) for a high risk of amputation. This is comparable to O'Banion et al. **[13]** findings, that ROC curve had an AUC of 0.750 and a score of >3 was observed the maximum sensitivity (85%) and specificity (49%) for a high risk of amputation.

The final POPSAVEIT **[13]** assigned a value of 2 points for the absence of pedal Doppler signals or 1 point for the absence of a palpable pedal pulse if the Doppler examination findings were not available. **(Table 1).** We agree with this distinction as other scoring methods either had a vague description of ischemia or relied on a pulse examination to assess the level of ischemia **[11,22,23]**, even though pulse examinations can be unreliable in non-expert hands, and they do not correlate well with ischemia severity **[24-26]**.

A Doppler examination and the ankle brachial index, on the other hand, have been demonstrated to be highly related to the severity of ischemia and limb threatening. **[27-29]** We found doing ankle brachial index in trauma patients practically difficult particularly in patients with unstable fractures, sever soft tissue damages and in non-experienced health personnel.

SBP of <90 mm Hg remains the most utilized cut off in the trauma surgery series to date as the criteria of hypotension. **[30]** In our series 23.6% of the patients presented with SBP of <90 mm Hg and out of the 14 patients that had a major amputation 10 initially presented with SBP of <90 mm Hg. This is comparable to the results demonstrated by O'Banion et al. **[13]**.

One of the factors the independently affects the outcome was the length /number of segments of popliteal artery injured; the whole length popliteal artery injury in the initial trauma was recorded as the highest percentage of amputation in our results.

Loss of primary patency was also correlated to the requirement for a major amputation. Of the 18 patients, 14 (77.8%) needed a major amputation, and all of them lost primary patency within 30 days. This is secondary to poor collateralization across the popliteal fossa particularly in severe trauma cases.

This is why some authors recommend long term surveillance for this cohort of patients. We do not offer this in our institute **[16]**.

Simplicity of the POPSAVEIT is a key potential advantage which contrasts with other scoring system like MESS which require specialized analysis to achieve the accurate score, therefore, POPSAVEIT, which is used to classify patients into high-risk versus low-risk groups for major amputation, appears to be accurate.

We agree with O'Banion et al. **[13],** that this score shouldn't be used to decide which patients should undergo reconstruction versus amputation as the maximum score (5) is associated with probability of amputation around 50%. It should be used as a guide to the team to identify high risk patients to help optimize them and actively improve the outcome.

Our study has drawbacks as it was a retrospective study in a single center with a small number of patients. There was no control group and the follow up was short. Other factors not included in POPSAVEIT like functional ambulatory status and anatomic details (e.g., nerve transection) may affect

the outcome. Nevertheless, POPSAVEIT is one step forward in assessment of patients with traumatic popliteal artery injury and future wide scale studies should be designed to further validate this score as a tool in the armamentarium of vascular specialist dealing with trauma.

CONCLUSION AND RECOMMENDATION

Traumatic popliteal artery injury accounts for 20% of the lower extremity vascular injuries and is associated with a high risk of amputation of the lower limb. Simplicity of POPSAVEIT is a key potential advantage to help identify stratify patients preoperatively into low- and high-risk categories for major amputation. POPSAVEIT is one step forward in assessment of trauma patients with injury of popliteal artery. Future wide scale studies should be designed to further validate this score as a tool in the armamentarium of vascular specialists dealing with trauma.

CONFLICT OF INTEREST: None.
FINANCIAL DISCLOSURE: None.
SUPPLEMENT: Table S1, Multivariate logistic regression

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SUPPLEMENTARY TABLE

Table S1: Multivariate logistic regression

Risk Factors	OR	P Value
Associated Orthopedic injury	6.1	**0.009**
Lack of preoperative Pedal doppler signals	8.3	**0.001**
SBP <90mm Hg	5.3	**0.05**

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